J. Elementol. 2008, 13(2): 227–234

THE EFFECT OF NITROGEN FERTILIZATION ON CONTENT OF MICROELEMENTS IN SELECTED ONIONS

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Abstract

The effect of nitrogen fertilization on microelements (iron, manganese, copper and zinc) content in the yield of onion (*Allium cepa* L. var. *cepa* Helm.), top onion (*Allium cepa* var. *proliferum* Targioni-Tozzetti) and shallot onion (*Allium cepa* L. var. *ascalonicum*) was examined in a three-year field experiment conducted at the Vegetable Experimental Station in Dołuje. Urea, ammonium nitrate and calcium nitrate were applied in two different nitrogen doses: 100 kg $N \cdot ha^{-1}$ and 200 kg $N \cdot ha^{-1}$. The bulbs were planted in field at the beginning of April. The planting density was 30 x 5 cm (onion) and 30 x 10 cm (top onion and shallot onion). During the growing season, the soil tillage and plant cultivation treatments were conducted according to standard methods. Onion and shallot onion were harvested during the last days of July or the first days of August, after 75% of the plants had bent leaves. Top onion was harvested at the end of September. The content of microelements in dry matter of the analyzed plants was determined by atomic absorption spectrometry, after wet mineralization of the samples in a mixture of concentrated nitric and perchloric acids mixed in a 3:1 ratio.

The applied nitrogen fertilization significantly affected microelements in all the tested onions. The content of iron and manganese in onion bulbs increased with the increasing nitrogen doses, while that of copper and zinc decreased. The analysis of the results led to a conclusion that a significant effect on the chemical composition of yield produced by onion, top onion and shallot onion was produced by the applied nitrogen dose but not its form. The content of microelements and extent of the changes caused by the nitrogen fertilization depended on the tested type of onion.

Key words: nitrogen fertilization, microelements content, onion, top onion, shallot.

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WPŁYW NAWOŻENIA AZOTEM NA ZAWARTOŚĆ MIKROELEMENTÓW W WYBRANYCH ODMIANACH BOTANICZNYCH CEBULI

Abstrakt

W trzyletnim doświadczeniu polowym przeprowadzonym w Warzywniczej Stacji Doświadczalnej w Dołujach badano wpływ nawożenia azotem na zawartość mikroelementów (żelaza, manganu, miedzi i cynku) w plonie cebuli zwyczajnej (*Allium cepa* L. var. *cepa* Helm.), cebuli piętrowej (*Allium cepa* var. *proliferum* Targioni-Tozzetti) i szalotki (*Allium cepa* L. var. *Ascalonicum*). Zastosowano następujące nawozy: mocznik, saletrę amonową i saletrę wapniową w zróżnicowanych dawkach nawożenia azotem – 100 i 200 kg $N \cdot ha^{-1}$. Cebulki wysadzano do gleby na początku kwietnia w rozstawie 30 x 5 cm (cebula zwyczajna) i 30 x 10 cm (cebula piętrowa i szalotka). W okresie wegetacji roślin wykonywano standardowe zabiegi pielęgnacyjne i agrotechniczne. Cebulę zwyczajną i szalotkę zbierano w ostatnich dniach lipca lub pierwszych dniach sierpnia, kiedy ok. 75% roślin miało załamany szczypior. Cebulę piętrową zbierano w końcu września. Zawartość mikroelementów w suchej masie badanych roślin oznaczano metodą absorpcyjnej spektrometrii atomowej, po wcześniejszym zmineralizowaniu próbek w mieszaninie stężonych kwasów azotowego(V) i chlorowego(VII) zmieszanych w stosunku 3:1.

Nawożenie azotem spowodowało istotne zmiany zawartości mikroelementów w plonie wszystkich badanych odmian. Pod wpływem wzrastających dawek azotu nastąpiło zwiększenie zawartości żelaza i manganu oraz zmniejszenie koncentracji miedzi i cynku.

Analiza statystyczna wyników wykazała, że czynnikiem istotnie odpowiedzialnym za zmiany w składzie chemicznym cebuli zwyczajnej, cebuli piętrowej i szalotki była zastosowana w nawożeniu dawka azotu, a nie rodzaj użytego nawozu. Zawartość oznaczanych mikroelementów oraz zakres zmian spowodowanych nawożeniem zależały od badanej odmiany botanicznej cebuli.

Słowa kluczowe: nawożenie azotem, mikroelementy, cebula zwyczajna, cebula piętrowa, szalotka.

INTRODUCTION

Owing to their nutritional, medicinal and taste values, bulbous vegetables are among the most popular vegetables in Poland. Although mainly used as seasoning vegetables, bulbs make an important contribution to man's diet, having many vitamins, flavonoids, macro- and microelements. There is a direct relationship between microelement nourishment of plants and health of plant consumers (Ruszkowska, Wojcieska-Wyskupajtys 1996).

Microelements, being components or activators of numerous enzymes, play a catalytic role in many life processes and are necessary for correct growth of humans, animals and plants. Such elements as iron, manganese, zinc or copper participate in photosynthesis, decarboxylation, processes of nitrogen fixation, metabolism of carbohydrates and proteins.

Among all the factors which intensify plant production, nitrogen fertilization is the most effective method. However, during intensive fertilization amounts of macro- and microelements taken up by plants may differ significantly. Changes in the composition of microelements in a plant can accelerate or inhibit certain physiological processes. As a consequence, the plant's is disturbed, leading to depressed yield or its reduced nutritional value.

The aim of the present study was to determine the effect of several forms and doses of nitrogen fertilizers applied in field cropping of onion (*Allium cepa* L. var. *cepa* Helm.), top onion (*Allium cepa* var. *proliferum* Targioni-Tozzetti) and shallot onion (*Allium cepa* L. var. *Ascalonicum*) on the content of some microelements like iron, manganese, copper and zinc absorbed by the plants.

MATERIAL AND METHODS

An experiment on three types of onion: onion, top onion and shallot onion, was carried out at the Vegetable Experimental Station in Dołuje in 2000-2003. The onions were cultivated on post-marshy soil (classified as typical black earth, of soil quality class IIIb) of pH_{KCl} 6.6-7.2. The experiment was set up in a randomized block design in four replications on 2.7 m^2 (1.8 x 1.5 m) plots, and included the following factors:

1st factor – forms of nitrogen fertilizer (urea, ammonium nitrate and calcium nitrate);

2nd factor – nitrogen dose (100 and 200 kg $N \cdot ha^{-1}$).

Each year before planting onion bulbs, the soil in all the experimental plots was fertilized with an identical dose of phosphorus (80 kg $P \cdot ha^{-1}$) and potassium (200 kg $K \cdot ha^{-1}$). Then, single applications of nitrogen, in different forms and rates, were applied. Onion bulbs were planted in early April at 30 x 5 cm (onion) and 30 x 10 cm (top onion and shallot) spacing. During the vegetative growth, the soil tillage and plant cultivation were conducted according to the specific recommendations for each variety. The plants were harvested when *ca* 75% of the plants' leaves began to wilt. The harvest date thus determined took place in late July or early August, depending on the weather conditions. Top onion was picked up in the last days of September.

From the marketable yield, about 2 kg of fresh onion bulbs was sampled randomly. After removing the shells, the bulbs were cut, dried at 60°C and ground to obtain uniform, representative material for chemical determinations. Total content of microelements in dry matter was determined by atomic absorption spectrometry following wet mineralization of the samples in a 3:1 mixture of concentrated nitric and perchloric acids.

The results were analysed statistically by means of two-factor variance analysis in a system of randomized blocks with one test field. Significance of differences between means was estimated by Tukey's test at significance level α=0.05.

RESULTS AND DISCUSSION

Nitrogen fertilization affected significantly the content of microelements in yields of bulb onion, top onion and shallot. Increased rates of nitrogen resulted in higher amounts of iron and manganese but depressed quantities of copper and zinc (Table 1). Increased content of iron and manganese in nitrogen-fertilized onion has been observed by Coolong et al. (2004). According to these authors, nitrogen fertilization also induced higher zinc content in onion while leaving the copper content unaffected. However, other studies on nitrogen fertilization of other crops (Czuba 1986, Sawicka 1996) prove that high dosage of nitrogen decreases the concentration of copper and zinc in the plants they examined.

The authors' own studies demonstrate that the three types of onion responded differently to the applied nitrogen fertilization. An average content of iron in onion, top onion and shallot was similar (41.86, 39.24 and 43.70 $mg \cdot kg^{-1}$ d.m., respectively). The fertilization treatments increased similarly the content of iron in onion and shallot. Bulbs of these onion species collected from the fertilized fields contained on average more iron than bulbs from the test field (by 11.6 and 10.9%, respectively). Regarding top onion, nitrogen fertilization increased the iron concentration by 14.5% on average.

The highest content of manganese was found in shallot (on average 10.36 $mg \cdot kg^{-1}$ d.m.), and the lowest one - in top onion (on average 7.50 $mg \cdot kg^{-1}$ d.m). Nitrogen fertilization raised the manganese content on average by 16.6% in onion, by 19.8% in top onion and 20.4% in shallot (as compared to the test field).

Statistical analysis of the results proved that the content of iron and manganese in dry matter of onion, top onion and shallot significantly increased following the application of higher nitrogen doses, being independent from the form of the applied fertilizer. The nitrogen dose of 200 kg $N \cdot ha^{-1}$ helped to increase the iron content (compared to the test field) by 13.8% in onion, by 20.3% in top onion and by 15.6% in shallot. The same nitrogen dose raised the manganese level by 24% in onion and by 27% in top onion and shallot.

Likewise, copper and zinc in onion, top onion and shallot were affected by the nitrogen dose and not its form. The content of copper and zinc in dry matter of the tested plants diminished significantly due to the increased nitrogen doses, whereas the form of nitrogen fertilizer had no particular effect.

The average amounts of copper in onion, top onion and shallot were similar: 6.02, 6.45 and 5.14 $mg \cdot kg^{-1}$ d.m., respectively. The biggest modification in the content of this element caused by the nitrogen fertilization occurred in top onion, and the smallest one – in shallot. The higher fertilization rate of 200 kg $N \cdot ha^{-1}$ decreased (compared to the test field) the copper content in top onion by 29.1% and in shallot by 16.6%.

Table 1

Effect of nitrogen fertilization on the content of microelements (mg·kg^{-1} d.m.) in selected onion cultivars (mean for three years)

Fertilizer object	Nitrogen dose*	Onion				Top onion				Shallot onion			
		Fe	Mn	Cu	Zn	Fe	Mn	Cu	Zn	Fe	Mn	Cu	Zn
Control	0	38.08	8.74	6.74	30.24	34.92	6.42	7.72	60.00	39.95	8.82	5.71	41.19
Urea	100	41.56	9.79	6.13	27.58	37.86	7.20	6.85	52.19	43.11	9.98	5.26	35.73
	200	44.14	11.06	5.57	23.25	43.10	8.22	5.38	45.64	46.76	11.14	4.81	31.73
Amonium nitrate	100	39.70	9.61	6.26	27.26	38.22	7.29	7.35	51.91	42.09	9.98	5.41	36.09
	200	44.38	11.17	5.59	23.55	41.53	8.36	5.35	46.42	45.96	11.67	4.65	32.32
Calcium nitrate	100	40.68	9.28	6.27	26.89	37.74	7.13	6.83	51.49	42.21	10.10	5.31	35.52
	200	44.46	10.21	5.58	23.68	41.37	7.91	5.69	45.15	45.85	10.86	4.81	32.91
		41.86	9.98	6.02	26.06	39.24	7.50	6.45	50.40	43.70	10.36	5.14	35.07
$\overline{x}$ for fertilizer objects		42.49	10.19	5.90	25.37	39.97	7.69	6.24	48.80	44.33	10.62	5.04	34.05
Mean for fertilizer forms													
Control		38.08	8.74	6.74	30.24	34.92	6.42	7.72	60.00	39.95	8.82	5.71	41.19
Urea		42.85	10.43	5.85	25.42	40.48	7.71	6.12	48.92	44.93	10.56	5.04	33.73
Amonium nitrate		42.04	10.39	5.93	25.41	39.88	7.83	6.35	49.17	44.03	10.83	5.03	34.21
Calcium nitrate		42.57	9.75	5.93	25.29	39.56	7.52	6.26	48.32	44.03	10.48	5.06	34.22
$LSD_{0.05}$		n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Mean for nitrogen dose													
0 (kg N·ha^{-1})		38.08	8.74	6.74	30.24	34.92	6.42	7.72	60.00	39.95	8.82	5.71	41.19
100 (kg N·ha^{-1})		40.65	9.56	6.22	27.24	37.94	7.21	7.01	51.86	42.47	10.02	5.33	35.78
200 (kg N·ha^{-1})		43.33	10.81	5.58	23.49	42.00	8.16	5.47	45.74	46.19	11.22	4.76	32.32
$LSD_{0.05}$		1.06	0.63	0.17	1.02	0.84	0.32	0.60	2.07	1.22	0.39	0.23	1.03

*(kg N·ha^{-1}); $\overline{x}$ – mean; n.s. – not significant

The three types of onion plants were highly diverse in zinc concentration. The highest content of this element was found in top onion (on average 50.40 mg·kg^{-1} d.m.), followed by shallot (on average 35.07 mg·kg^{-1} d.m.), and onion (on average 26.06 mg·kg^{-1} d.m.). In the analysed onions, nitrogen fertilization caused similar reduction (compared to the test field) in the zinc content (by, on average, 16.1% in onion, 17.3% in shallot and 18.75 in top onion). The zinc content in dry matter of bulbs from the fields fertilized with 200 kg N·ha^{-1} was 21–23% lower (depending on the type of onion) compared to the zinc content found in dry mass of bulbs from the test field.

The three types of onion plants responded differently to nitrogen fertilization, which confirms earlier observations by LANCASTER et al. (2001), ABBEY et al. (2002), ARIYAMA et al. (2006). The largest variations in the content of microelements caused by the applied fertilization occurred in top onion; however, the levels of microelements were either similar or lower than those observed in the two other types of onion.

It should be noted that the changes in the accumulation of microelements due to the nitrogen fertilization in onion, top onion and shallot did not deteriorate their biological value, since the determined concentrations of the microelements were within the threshold limits set for foodstuffs (Regulation of the Minister for Health of 13 January 2003, published in the Journal of Law no 37, of 4 March 2003).

CONCLUSIONS

1. Increasing nitrogen fertilization raised the content of iron and manganese and decreased the amount of copper and zinc in bulbs of all studied onions.

2. Content of microelements in onion, top onion and shallot significantly depended on the applied nitrogen dosage but was independent from the fertilizer form whereas (urea, ammonium nitrate and calcium nitrate).

3. The types of onion plants differed in the modifications of the content of microelements content caused by nitrogen fertilization.

REFERENCES

ABBEY L., JOYCE D.C., AKED J., SMITH B. 2002. *Genotype, sulphur nutrition and soil type effects on growth and dry-matter production of spring onion.* J. Hort. Sci. Biotech., 77(3): 340-345.

ARIYAMA K., NISHIDA T., NODA T., KADORURA M., YASUI A. 2006. *Effects of fertilization, crop year, variety, and provenance factors on mineral concentrations in onions*. J. Agr. Food Chem., 54(9): 3341-3350.

COOLONG T.W., KOPSELL D.A., KOPSELL D.E., RANDLE W.M. 2004. *Nitrogen and sulfur influence nutrient usage and accumulation in onion.* J. Plant Nutr., 27(9): 1667-1686.

CZUBA R. 1986. *Zmiany zawartości składników w roślinach uprawnych na terenie kraju w zależności od nawożenia*. Mat. Symp. *Wpływ nawożenia na jakość plonów*. Olsztyn, 24-25 czerwca 1986, 1: 34-42.

LANCASTER J. E., FARRANT J., SHAW M. L. 2001. *Sulfur nutrition affects cellular sulfur, dry weigh distribution, and bulb quality in onion.* J. Amer. Soc. Hort. Sci., 126: 164-168.

Regulation of the Minister of Health dated 13 January 2003, published in the Journal of Law no 37, of 4 March 2003).

RUSZKOWSKA M., WOJCIESKA-WYSKUPAJTYS U. 1996. *Mikroelementy – fizjologiczne i ekologiczne aspekty ich niedoborów i nadmiarów.* Zesz. Probl. Post. Nauk Rol., 434: 1-11.

SAWICKA B. 1996. *Wpływ niektórych czynników agrotechnicznych na zawartość cynku i miedzi w bulwach Hellanthus tuberosus L.* Zesz. Probl. Post. Nauk Rol., 434: 231-235.